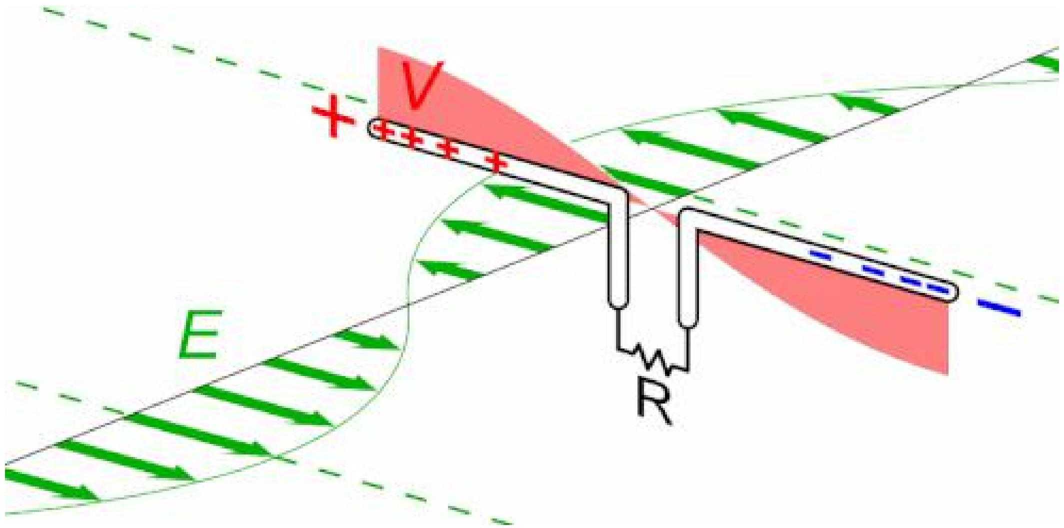
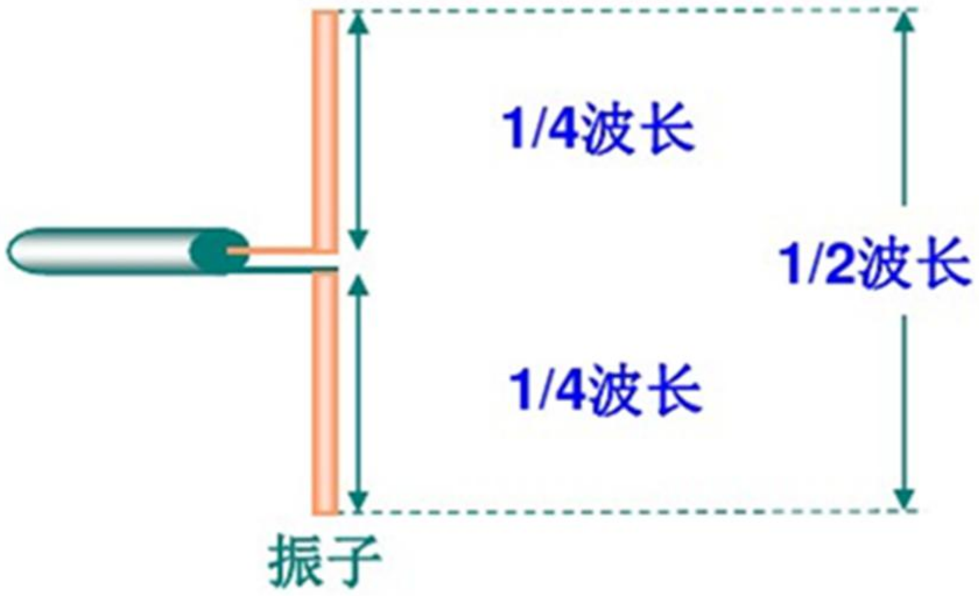
Selection of electric field antenna and measurement result

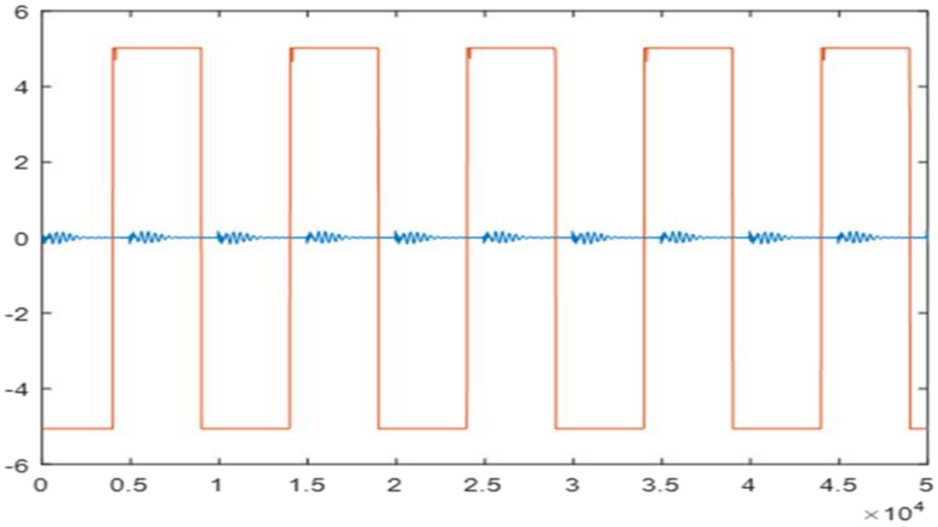
Xian Ming-Zheng

2020/10/14

Antenna theory and selection







$$Length\ of\ antenna = (1/2)\lambda = 1m$$

$$\lambda = c/f$$

$$\lambda = 2m \qquad f = 150MHz$$

Antenna theory and selection

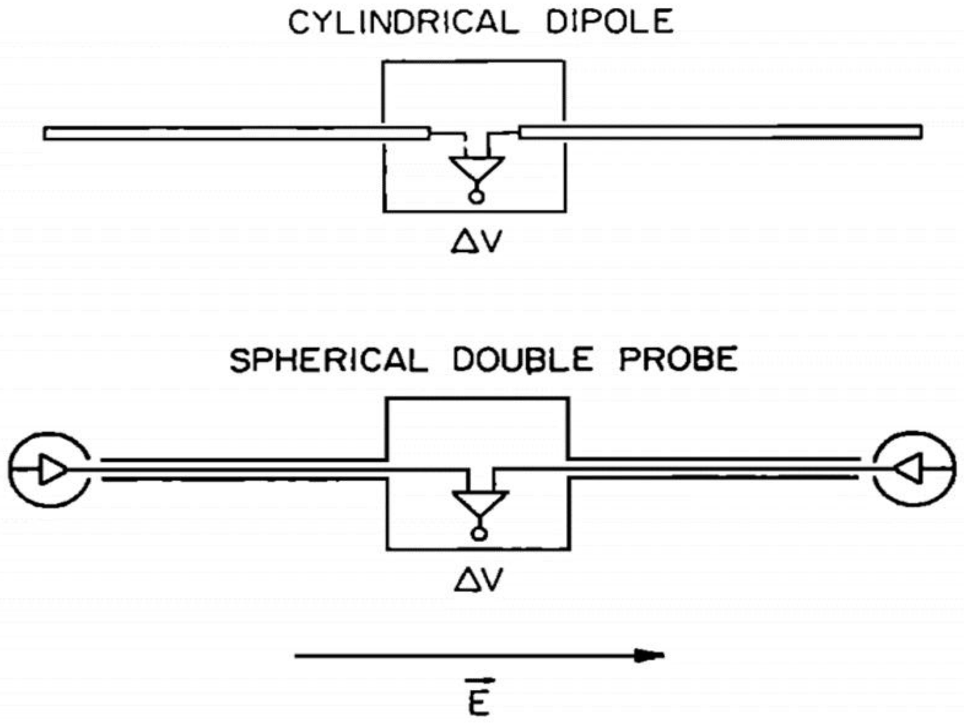


Figure 3. The geometry of a cylindrical electric dipole antenna and a spherical double probe. A differential amplifier in the spacecraft body provides a voltage output, ΔV, that is proportional to the voltage difference between the elements.

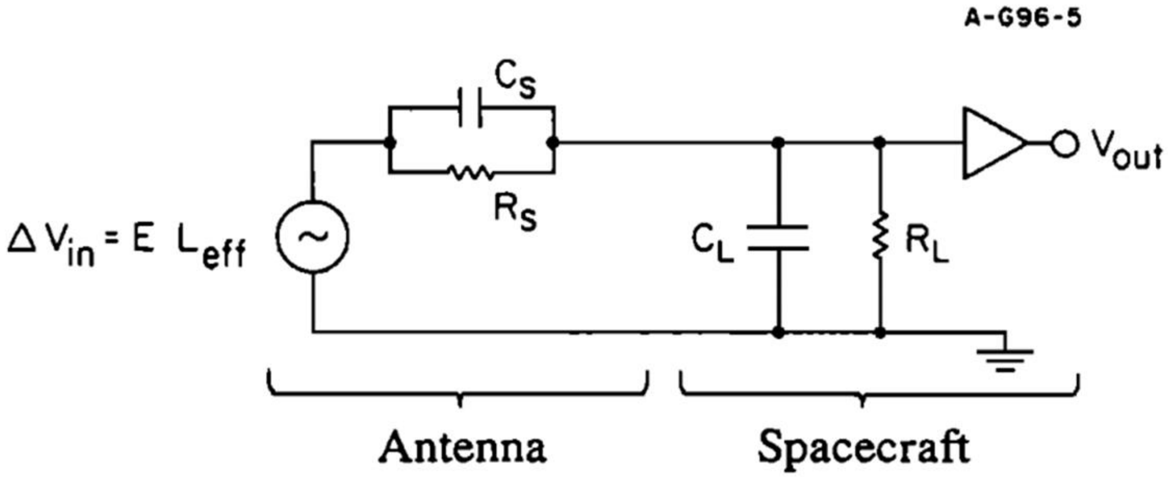


Figure 8. The equivalent circuit of an antenna immersed in a plasma. The resistance and capacitance of the sheath are represented by R_S and C_S , and the resistance and capacitance of the load are represented by R_L and C_L.

【Donald A. Gurnett ,1998】

Antenna theory and selec

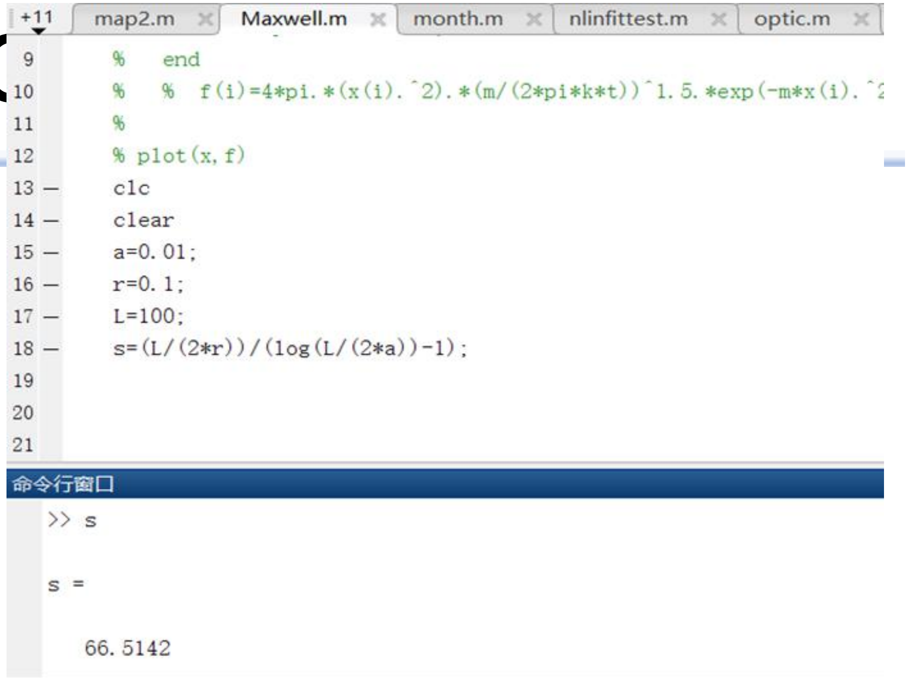
High Frequency Limit

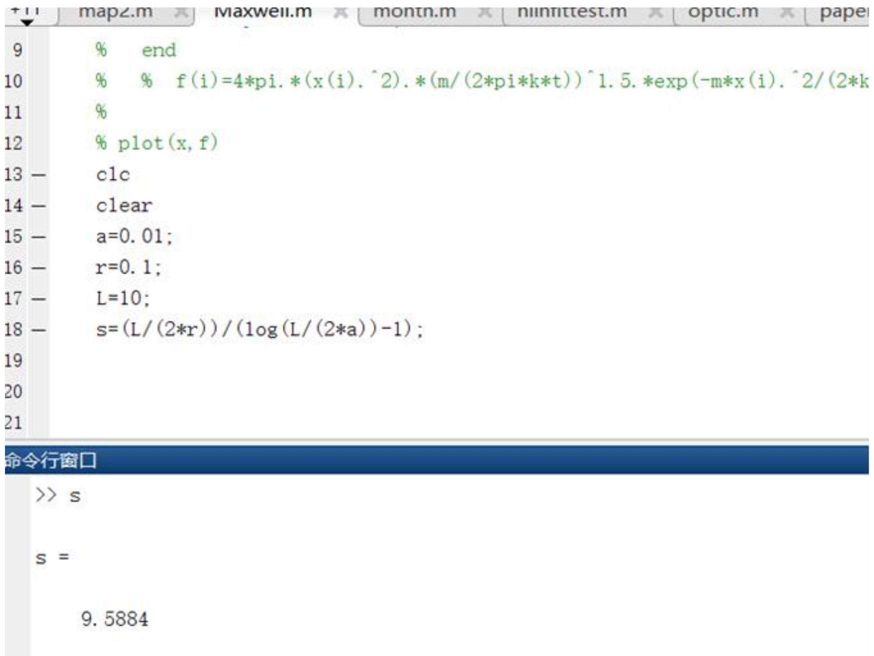
$$C_A = \frac{2\pi\epsilon_0(L/2)}{[\ell n(L/2a) - 1]} ,$$

$$C_A = 4\pi\epsilon_0 r \quad .$$

$$\frac{V_{out}}{E\ L_{eff}} = \frac{C_A}{C_A + C_L} \quad .$$

1000PF   10PF





Antenna theory and selection

Low Frequency Limit

$$C_S = \cancel{2\pi}\epsilon_0(L/2)/\ell n(\lambda_D/a) \quad ,$$

$$C_S = \cancel{4\pi}\epsilon_0 r\left(1 + \frac{r}{\lambda_D}\right) \quad ,$$

$$\frac{\Delta V_{out}}{E L_{eff}} = \frac{Z_L}{Z_A + Z_L} \quad .$$

$$\frac{\Delta V_{out}}{E L_{eff}} = \frac{R_L}{R_S + R_L} \quad .$$

$$R_S = \frac{U_e}{I_p + I_i + \cancel{I_{Bias}}}$$

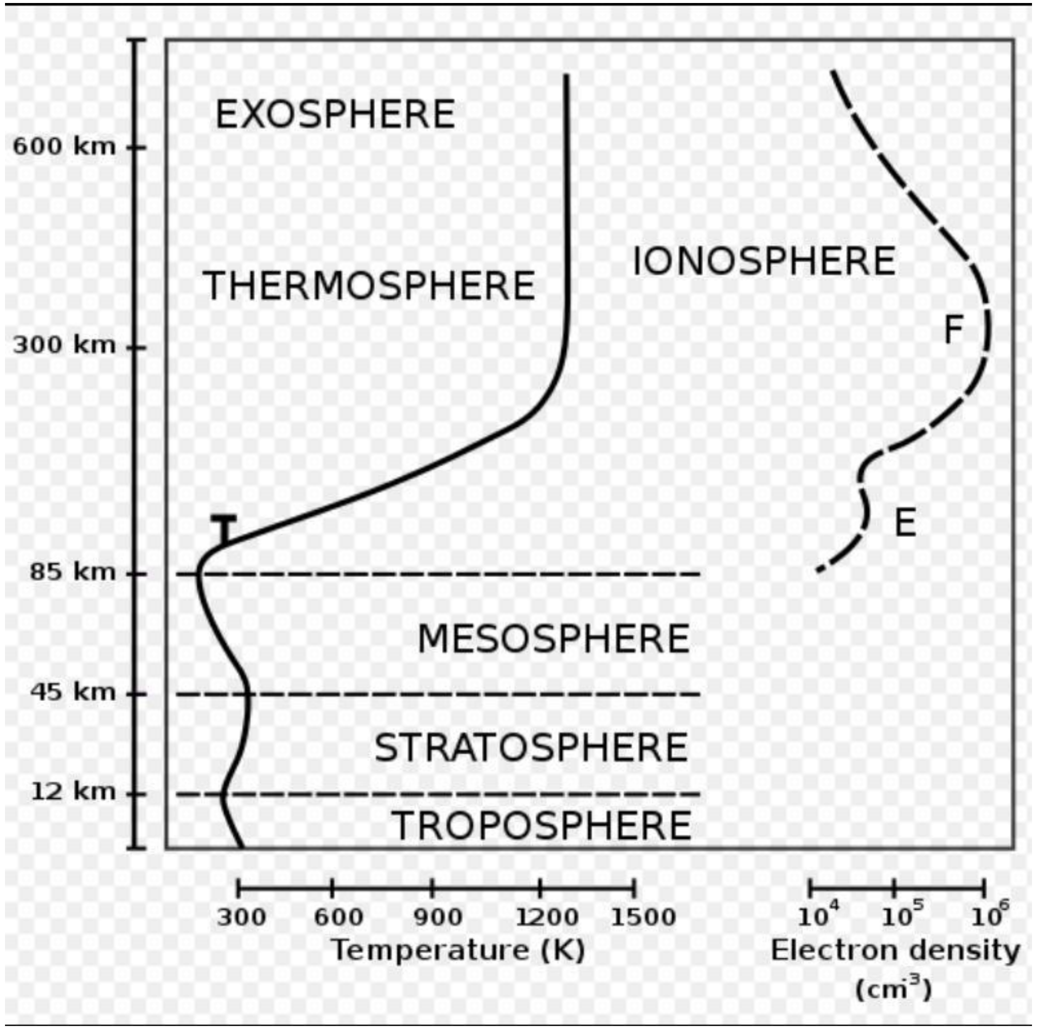
where $U_e = \kappa T_e/e$ is the electron temperature expressed in Volts, I_p is the emitted photoelectron current, and I_i is the incident ion current.

$$R_S = \frac{U_p}{I_e - I_i - \cancel{I_{Bias}}} \quad ,$$

where $U_p \approx 1.5$ Volts is the characteristic energy of the photoelectron spectrum (see *Cauffman and Gurnett* [1972]).

$$I_e + I_i + I_P = 0$$

Antenna theory and selection



K is boltzman constant.

K=8.6173324(78)× 10-5 (eV K-1).

When T=300K,$K \cdot T$ is about 0.026ev.

$$R_{Ssy} < R_{Ssp}$$

Benefit of choosing spherical probe

Short Wavelength Effects

Electrostatic waves can sometimes have very short wavelengths. The theoretical minimum wavelength is given by $\lambda = 2\pi/\lambda_D$. If the wavelength is comparable or shorter than the length of the antenna, then the response deviates considerably from the long wavelength limit discussed in

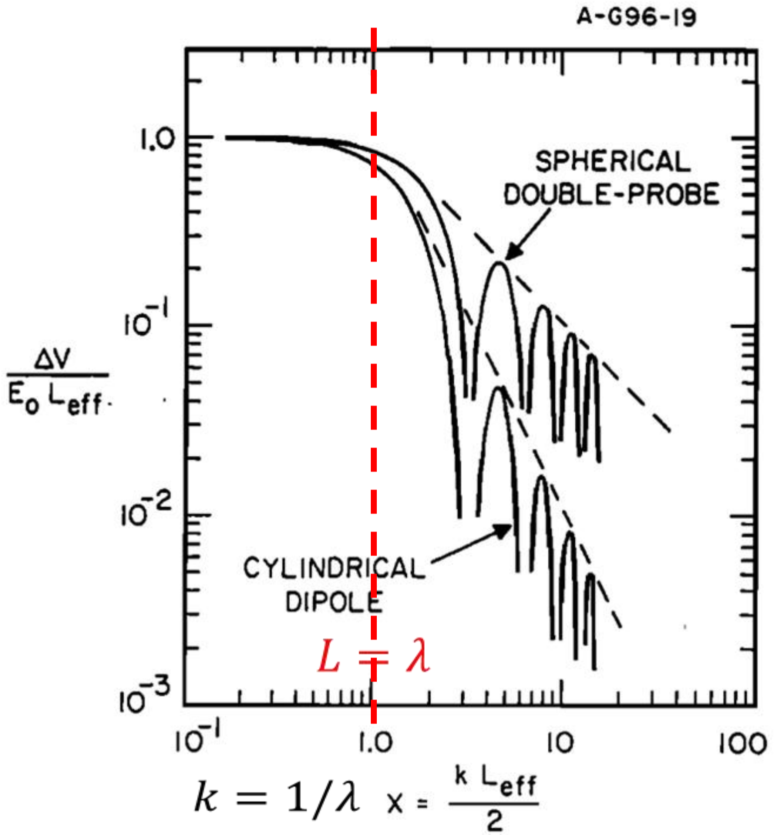
Z_L, the response of a cylindrical dipole is given by

$$\frac{\Delta V_{out}}{E_0 L_{eff}} = \frac{\sin^2 x}{x^2} , \qquad (12)$$

where $x = k\, L_{eff}/2$ is the normalized wave number and $L_{eff} = L/2$. For a spherical double probe, the analysis is even simpler, since the spheres can be regarded as two point probes. The corresponding result for a spherical double probe is given by

$$\frac{\Delta V_{out}}{E_0 L_{eff}} = \frac{\sin x}{x} , \qquad (13)$$

where in this case $L_{eff} = L$.

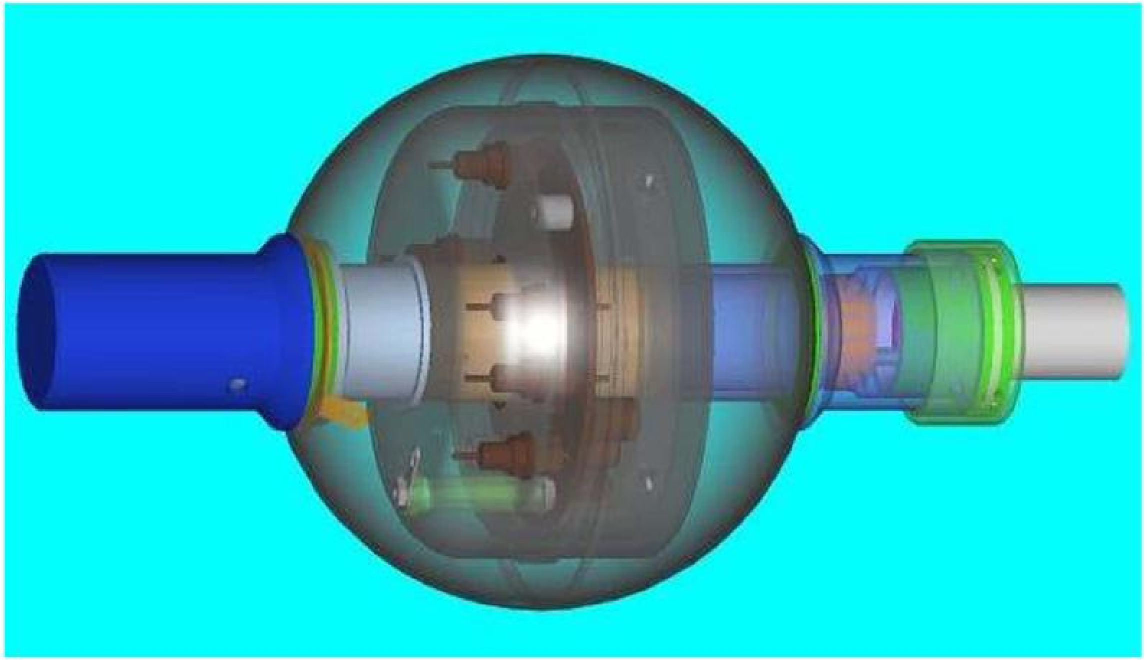


Benefit of choosing spherical probe

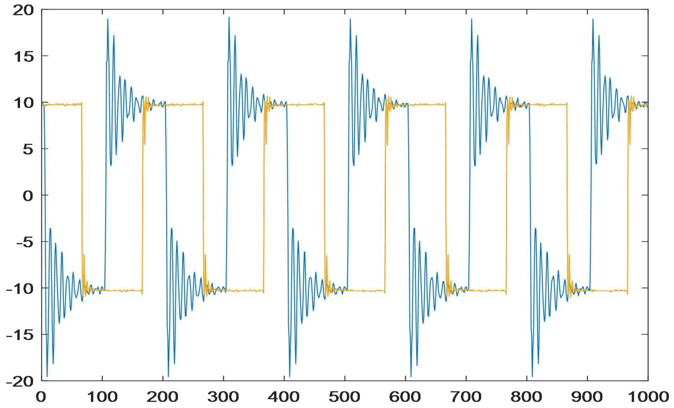
球形探针结构与电子学设计

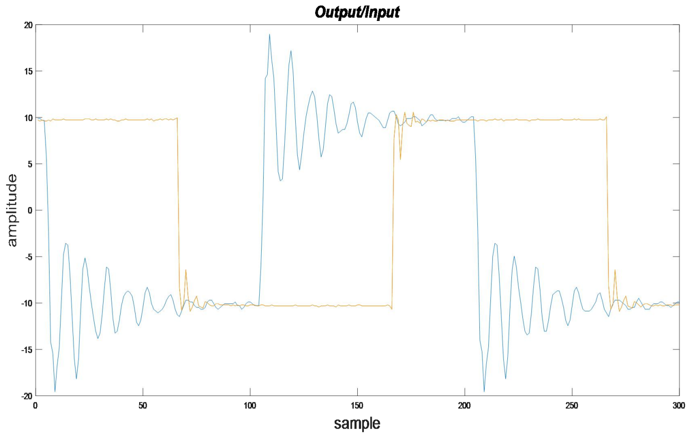
张衡一号空间电场球形探针结构具有以下优势:

- 易于实现一致性和对称性
- 相对接收面积大，灵敏度高
- 受太阳辐照入射角度影响小
- 可易于内置前置放大器和恒流源偏置
- 可有效降低耦合电容干扰
- 两端对称设计可抵消光照引起的光电子流发射不一致性

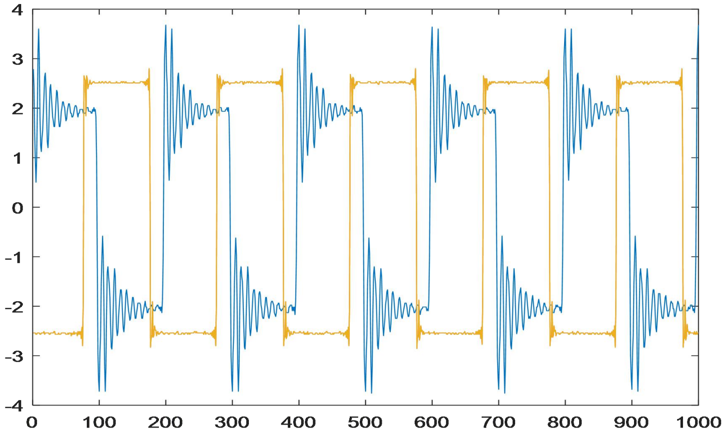


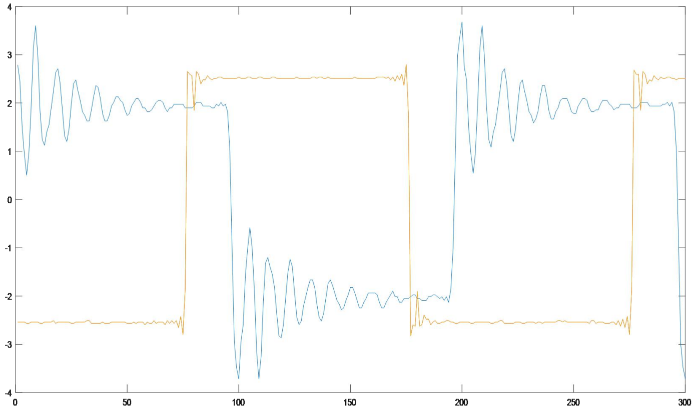
Antenna: measurement result





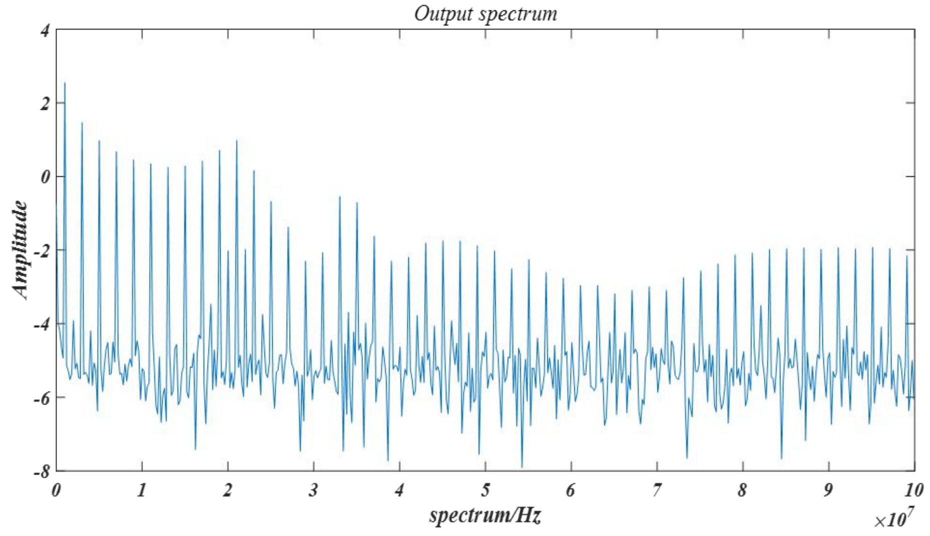
Fs=2*10^7Hz

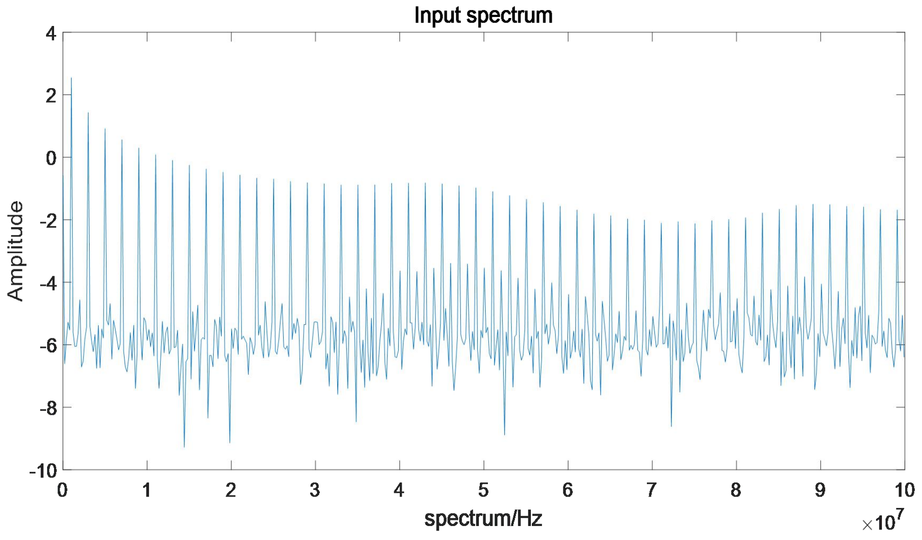


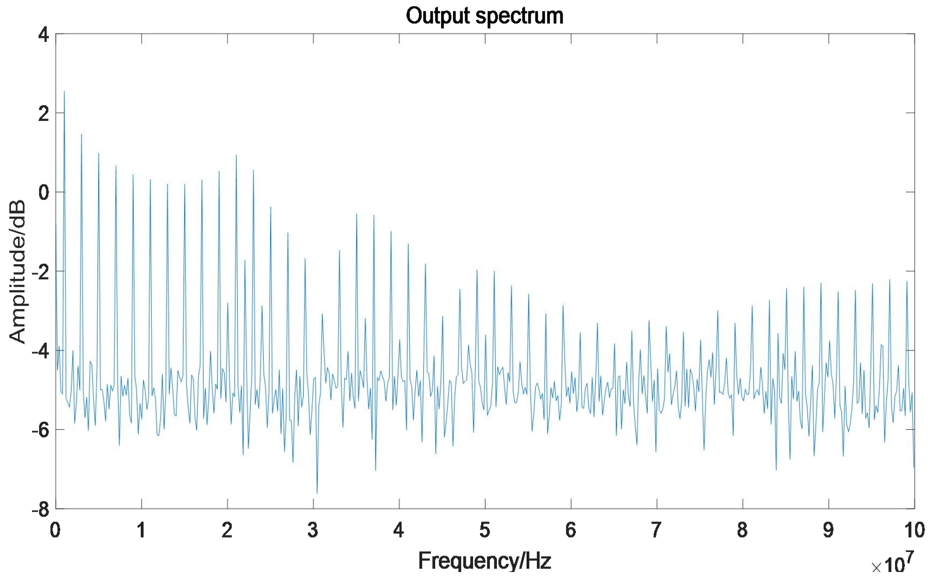


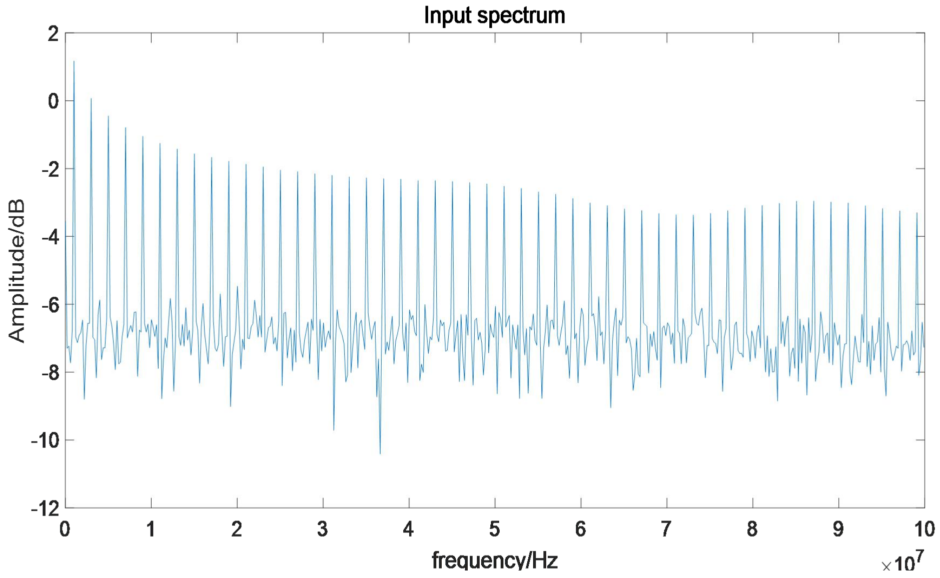
Fs=10*10^9Hz

Antenna: measurement result

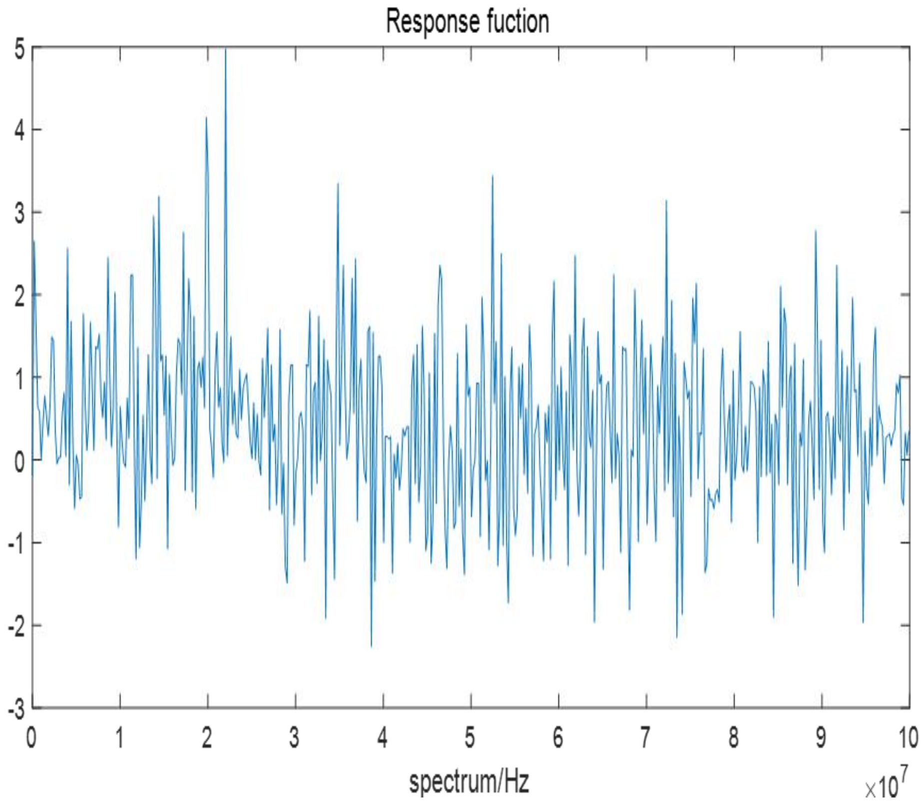


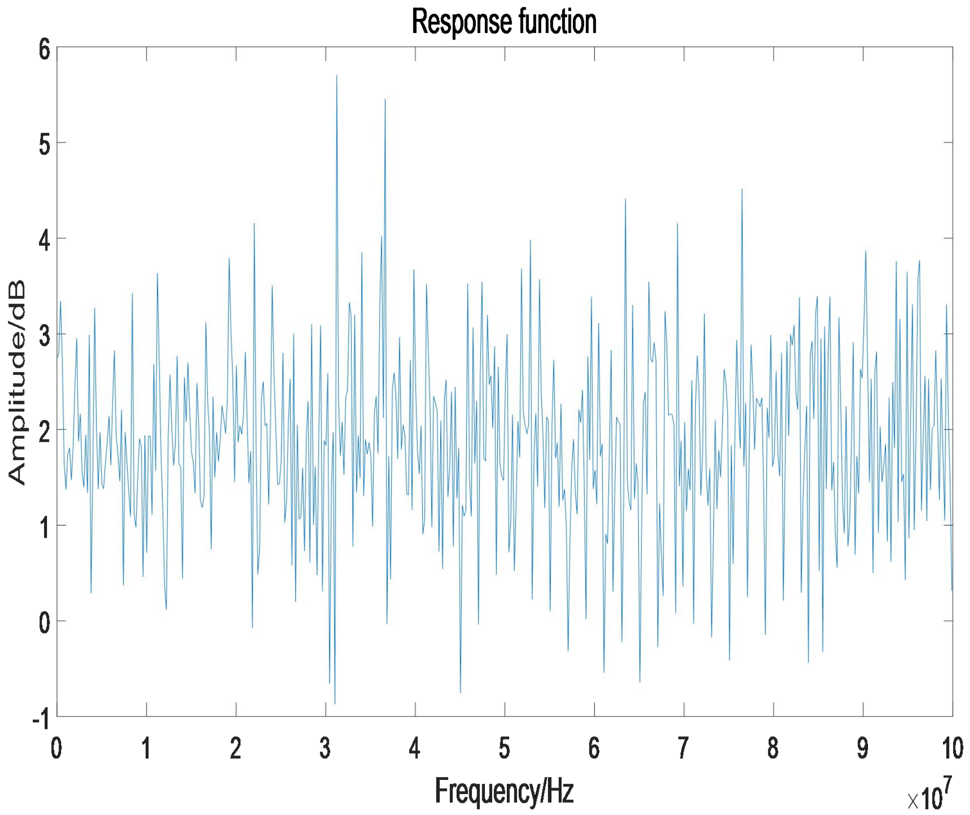




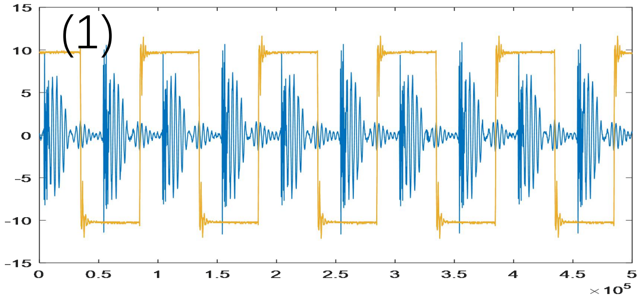


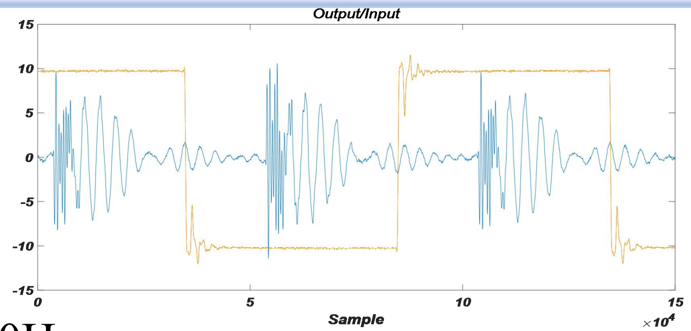
Antenna: measurement result



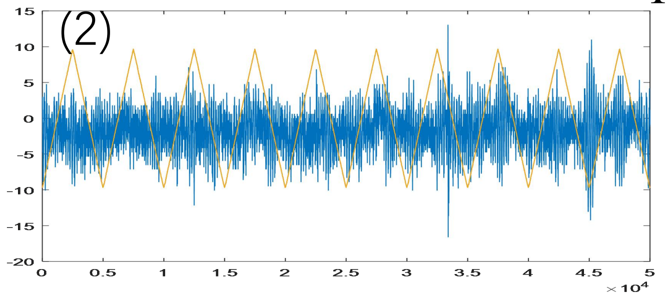


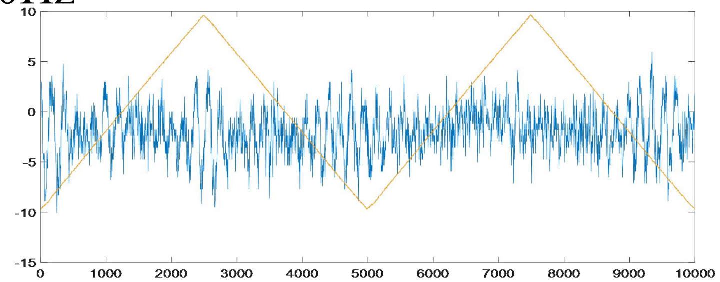
Antenna: measurement result



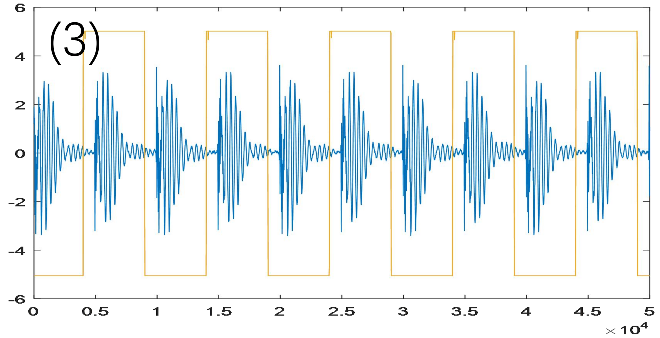


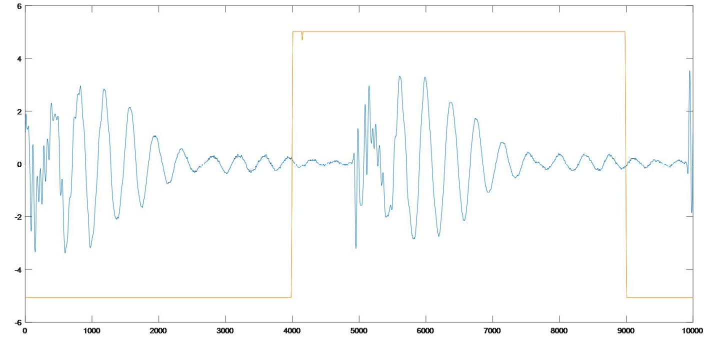
Fs=10^10Hz





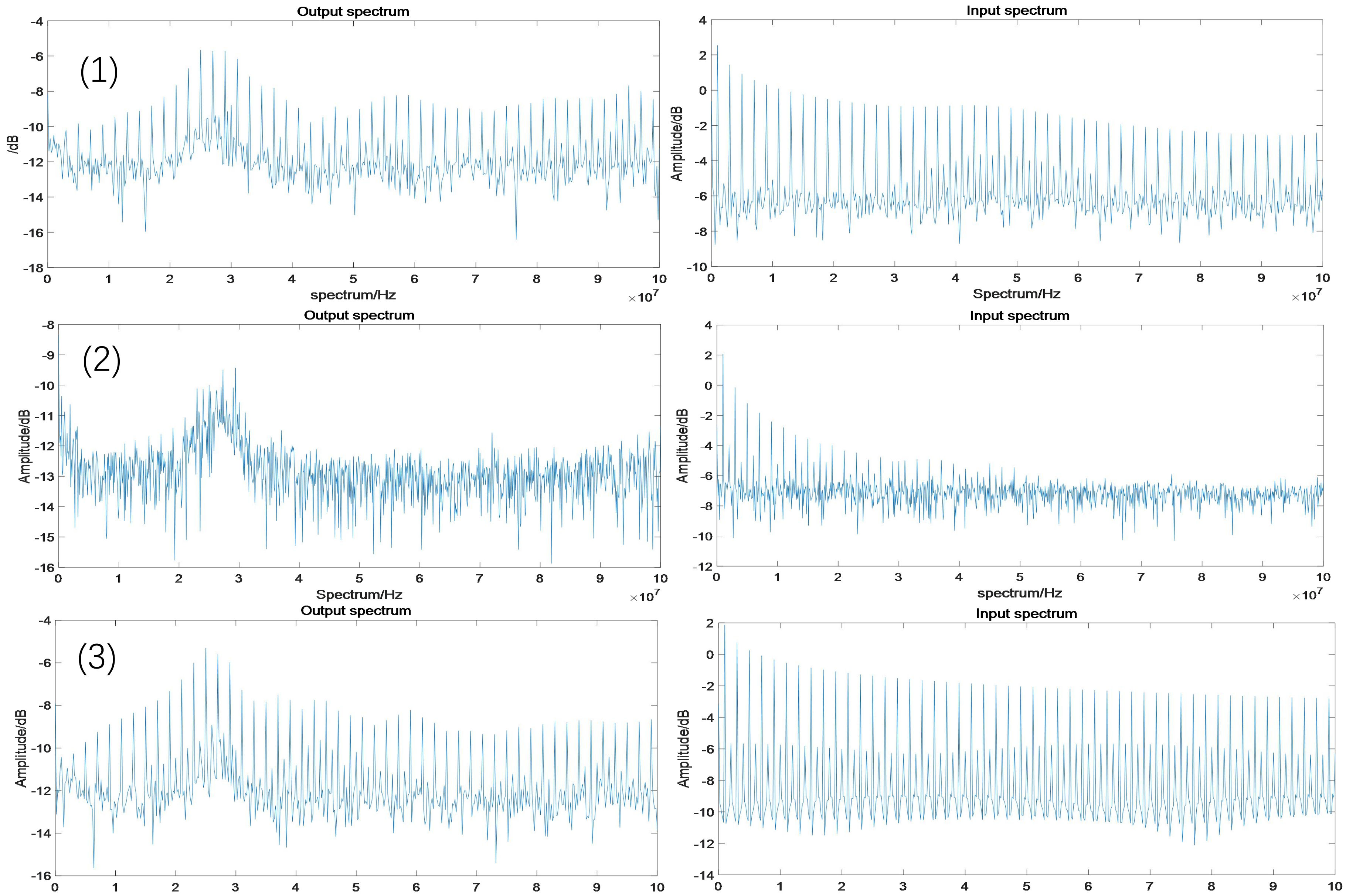
Fs=2.5*10^9Hz



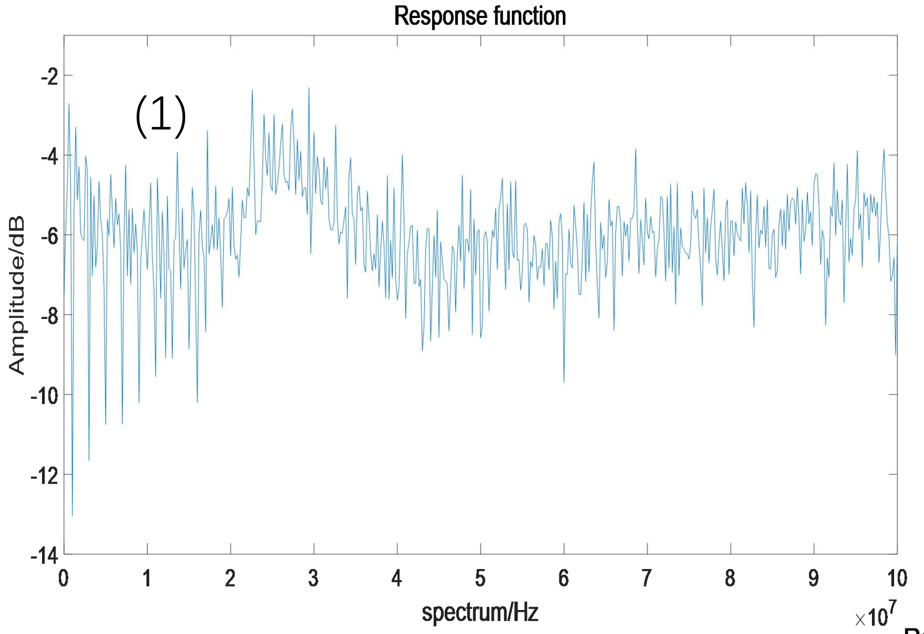


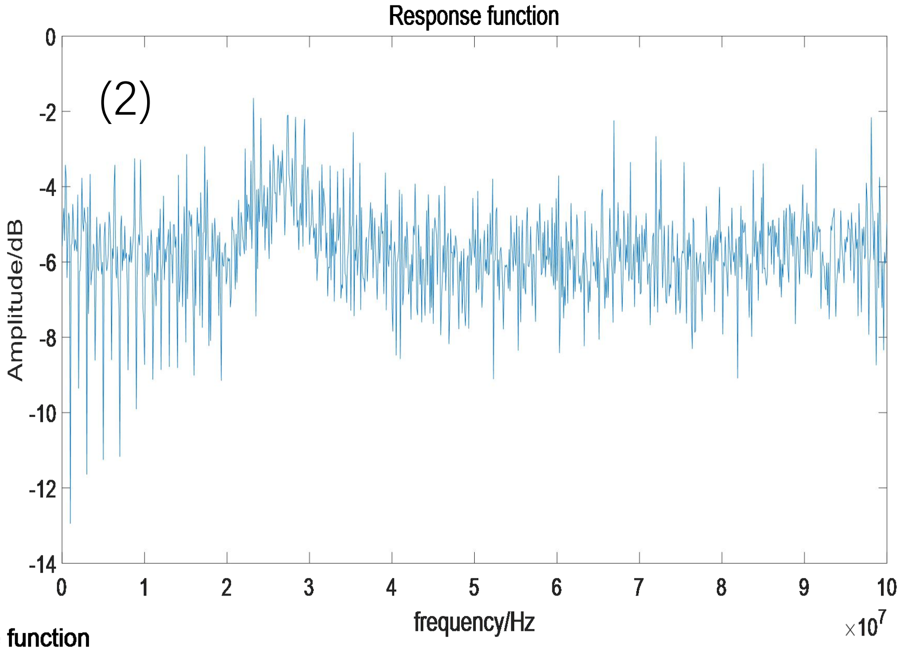
Fs=2*10^7Hz

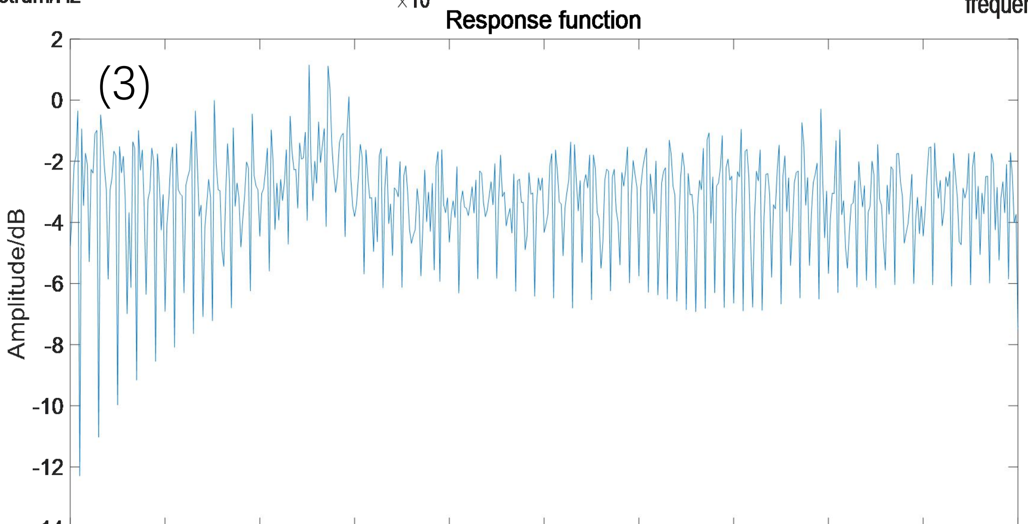
Antenna: measurement result



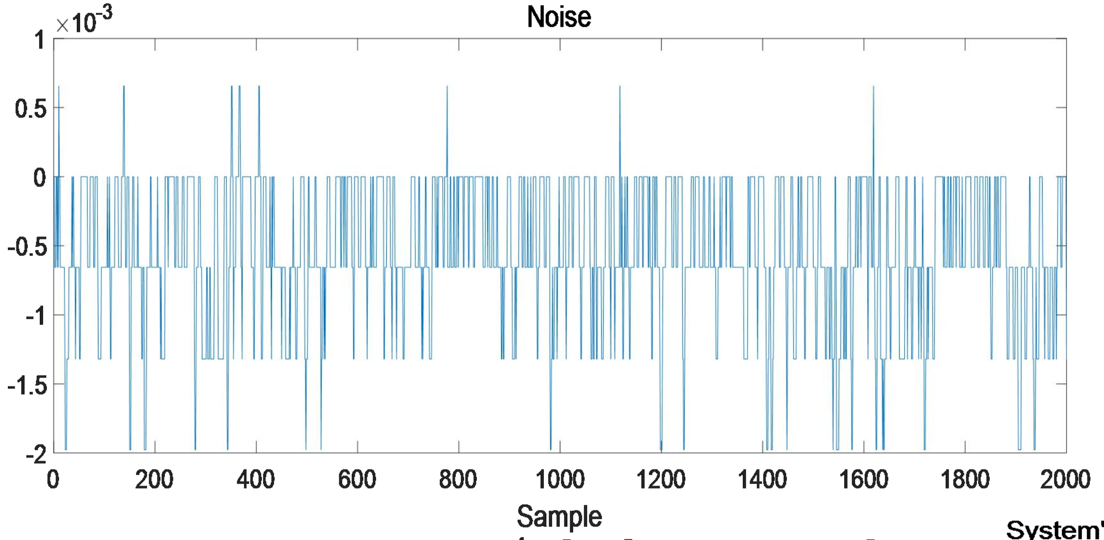
Antenna: measurement result

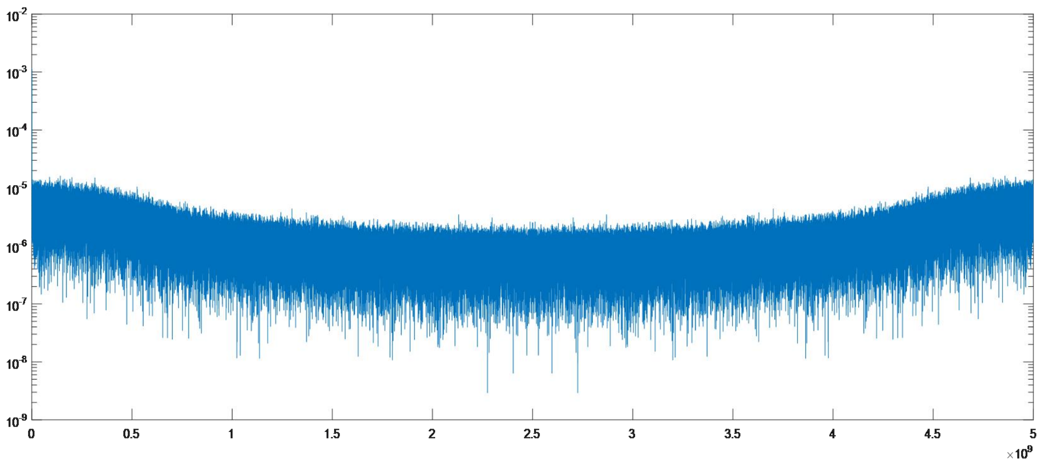


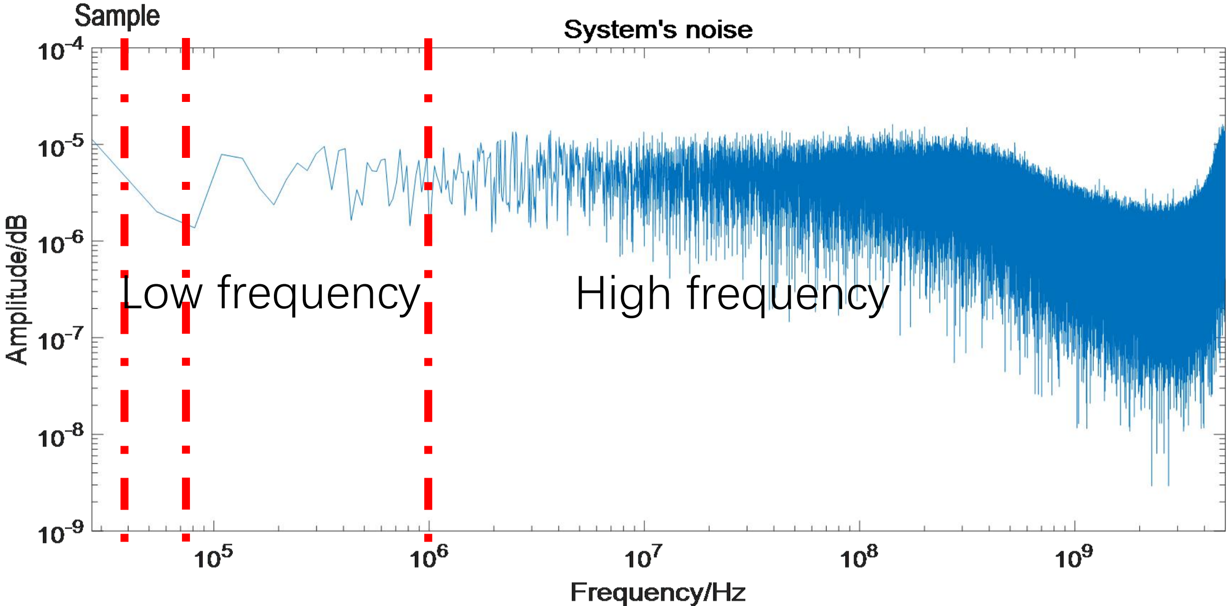




System: measurement result







Left question

Properties of the Fourier Transform

$$x(t) \leftrightarrow X(\omega) \qquad y(t) \leftrightarrow Y(\omega)$$

- *Linearity:*

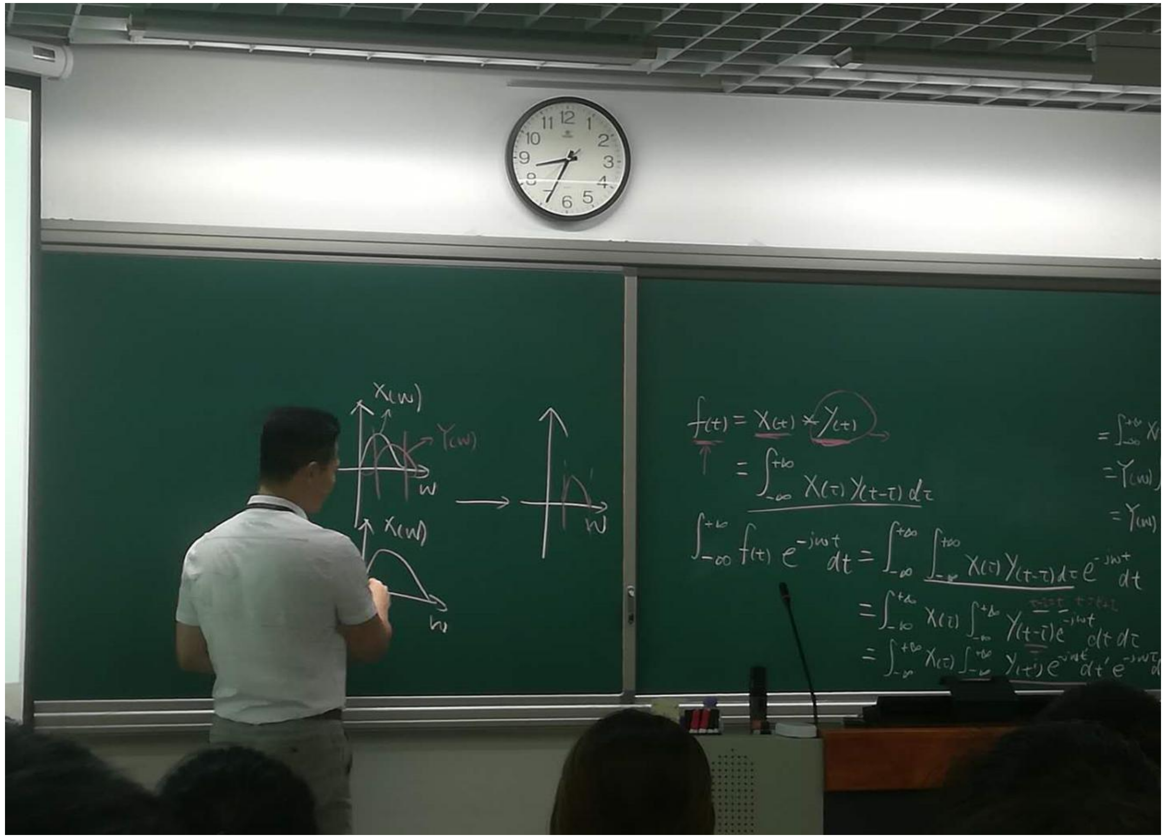
$$\alpha x(t) + \beta y(t) \leftrightarrow \alpha X(\omega) + \beta Y(\omega)$$

- *Left or Right Shift in Time:*

$$x(t - t_0) \leftrightarrow X(\omega) e^{-j\omega t_0}$$

- *Time Scaling:*

$$x(at) \leftrightarrow \frac{1}{a} X\left(\frac{\omega}{a}\right)$$



$$Y(\omega) = X(\omega) \cdot H(\omega)$$

SDR: 连续频率范围：100 kHz - 3.8 GHz